Medical Progress

Radiologic Imaging Modalities, Including Magnetic Resonance, for Evaluating Lymph Nodes

GEORGES C. DOOMS, MD, *Brussels, and* HEDVIG HRICAK, MD, *San Francisco*

Although lymphography may be more accurate in assessing the extent of abdominal and pelvic Hodgkin's lymphoma, computed tomography (CT) has similar or greater overall accuracy than other imaging modalities in detecting malignant lymph nodes in the neck, chest, abdomen and pelvis. In this early stage of magnetic resonance (MR) imaging, its depiction of nodes is apparently mostly similar to that of CT. In addition, MR imaging shows the capacity to distinguish between enlarged lymph nodes caused by acute inflammation and those caused by malignant processes.

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Many reports have been published about the accuracy of various radiologic imaging modalities—including computed tomography, lymphography, ultrasonography, gallium scanning, plain chest radiography, conventional tomography, excretory urography and cavography—in detecting malignant lymph nodes in the neck, chest, abdomen and pelvis.[1-92] In this review we evaluate the accuracy, sensitivity and specificity, advantages and disadvantages of the various imaging modalities used for detecting malignant lymph nodes. In addition, we discuss the present role of magnetic resonance (MR) imaging in the staging of malignant diseases.

The Approach

A total of 92 published reports were reviewed to determine the mean sensitivity, specificity and overall accuracy of each imaging modality in detecting malignant lymph nodes in the chest, abdomen and pelvis. Only published reports with histologic correlation were used.

The sensitivity, specificity and overall accuracy were defined as follows:

$$\text{sensitivity} = \frac{\text{true-positives}}{\text{true-positives} + \text{false-negatives}}$$

$$\text{specificity} = \frac{\text{true-negatives}}{\text{true-negatives} + \text{false-positives}}$$

$$\text{overall accuracy} = \frac{\text{true-positives} + \text{true-negatives}}{\text{total number of tests}}$$

In calculating the sensitivity, specificity and overall accuracy, equivocal results in the reports were considered to be true-negative or false-negative, depending on the histologic findings.

The mean overall accuracy was determined by combining all data from the same imaging modality and the same disease into a single study. This yields the same result as a weighted average of the individual studies. The same technique was used to calculate the mean sensitivity and specificity.

In some cases, the data do not seem horizontal because it was impossible to determine the values of the three measurements (sensitivity, specificity and overall accuracy) from some reports.

The role that MR imaging can play in the staging of malignant disease (detecting malignant lymph nodes in patients with lymphoma and carcinoma) was determined using the findings of two previously reported retrospective studies of 84 and 86 patients.[93,94]

The Findings

The mean overall accuracy, sensitivity and specificity of the various imaging modalities used in the staging of lymphoma (Hodgkin's and non-Hodgkin's) and detecting carcinomatous nodes are given in Tables 1 through 4. Table 5 presents the ranges of the overall accuracy, sensitivity and specificity from the different reports arranged according to the type of disease and imaging modality.

Variability of the Overall Accuracy, Sensitivity and Specificity From Various Reports and Need for Determining the Mean Value

There are many reasons why the reported overall accuracy, sensitivity and specificity of imaging modalities vary so greatly (Table 5). First, the criteria for diagnosing positive lymph nodes differ from one report to another. In the case of

From the Department of Radiology, University of California, San Francisco, School of Medicine. Dr Dooms is now with the Université Catholique de Louvain Faculté de Médecine, Brussels.

Reprint requests to Hedvig Hricak, MD, Department of Radiology, University of California, San Francisco, School of Medicine, San Francisco, CA 94143.

ABBREVIATIONS USED IN TEXT
CT = computed tomography
MR = magnetic resonance

computed tomography, for example, if the CT criterion for diagnosing positive (malignant) lymph nodes on the basis of size is placed at 12 mm or greater, there will be more false-negative and fewer false-positive reports (resulting in increased specificity but decreased sensitivity) than if the CT criterion for positive lymph nodes is placed at 10 mm and above.

Second, the value of these measurements depends on the type and stage of disease. One report, for example, shows that lymphography and CT are less sensitive for the early than for the advanced stages of disease (55.6% versus 80% and 44.4% versus 75%, respectively).[54] The fact that various reports are based on either early or advanced stages, or both, accounts in part for the great variability.

Third, the results depend on experimental variables, such as the sensitivity of the equipment and the ability of a physician to do and interpret the examination. Older, more primitive equipment had poor spatial resolution, and some significantly enlarged lymph nodes were overlooked. Ultra-

TABLE 1.—*Reported Accuracy of Various Imaging Modalities in Detecting Mediastinal Lymph Node Metastases From Bronchogenic Carcinoma*

Reports	*Number of Patients*	*Imaging Modality*	*Sensitivity* Percent*	*Specificity* Percent*	*Overall Accuracy* Percent*
De Meester et al, 1976[1]; Shevland et al, 1978[2]; Hirleman et al, 1980[3]	123	Gallium scanning	62 (34/55)	75 (51/68)	69 (85/123)
Shevland et al, 1978[2]; Hutchison and Mills, 1976[4]; Faling et al, 1981[5]; Osborne et al, 1982[6]	218	Plain chest radiographs	54 (53/99)	92 (109/119)	74 (162/218)
Shevland et al, 1978[2]; Hirleman et al, 1980[3]; Osborne et al, 1982[6]	126	Conventional tomography	66 (38/58)	94 (64/68)	81 (102/126)
Shevland et al, 1978[2]; Hirleman et al, 1980[3]; Faling et al, 1981[5]; Osborne et al, 1982[6]; Crowe et al, 1978[7]; Underwood et al, 1979[8]; Mintzer et al, 1979[9]; Eckholm et al, 1980[10]; Rea et al, 1981[11]; Baron et al, 1982[12]	442	Computed tomography	82 (143/175)	84 (223/267)	83 (366/442)

*See text for definitions of Sensitivity, Specificity and Overall Accuracy.

TABLE 2.—*Reported Accuracy of Various Imaging Modalities in Detecting Hilar Lymph Node Metastases From Bronchogenic Carcinoma*

Reports	*Number of Patients*	*Imaging Modality*	*Sensitivity* Percent*	*Specificity* Percent*	*Overall Accuracy* Percent*
De Meester et al, 1976[1]; Shevland et al, 1978[2]; Hirleman et al, 1980[3]	95	Gallium scanning	71 (36/51)	59 (26/44)	65 (62/95)
Faling et al, 1981[5]; Osborne et al, 1982[6]	77	Plain chest films	59 (19/32)	84 (38/45)	74 (57/77)
Shevland et al, 1978[2]; Hirleman et al, 1980[3]; Osborne et al, 1982[6]; Mintzer et al, 1979[9]	129	Conventional tomography	83 (59/71)	83 (48/58)	84 (92/109)
Shevland et al, 1978[2]; Hirleman et al, 1980[3]; Faling et al, 1981[5]; Osborne et al, 1982[6]; Mintzer et al, 1979[9]; Baron et al, 1982[12]	224	Computed tomography	70 (72/103)	92 (111/121)	83 (170/204)

*See text for definitions of Sensitivity, Specificity and Overall Accuracy.

TABLE 3.—*Reported Accuracy of Various Imaging Modalities in Detecting Lymph Nodes in the Abdomen and Pelvis Involved By Lymphoma and Lymph Node Metastases*

Reports	*Number of Patients*	*Imaging Modality*	*Sensitivity* Percent*	*Specificity* Percent*	*Overall Accuracy* Percent*
Kay and McCready, 1972[13]; Turner et al, 1972[14]; Moran et al, 1975[15]; Rochester et al, 1977[16]	501 (sites)	Gallium scanning†	55 (136/248)	95 (240/253)	75 (353/472)
Goffinet et al, 1973[17]; Baum et al, 1963[18]; Abrams et al, 1968[19]	111	Excretory urography‡	34 (38/111)	Not reported	Not reported
Moran et al, 1975[15]; Rochester et al, 1977[16]; Baum et al, 1963[18]; Abrams et al, 1968[19]; Dunnick and Javadpour, 1981[20]	193	Cavography‡	49 (76/154)	82 (32/39)	63 (72/114)
Rochester et al, 1977[16]; Tyrrell et al, 1977[21]; Brascho et al, 1977[22]; Frick et al, 1979[23]; Burney and Klatte, 1979[24]; Williams et al, 1980[25]; Beyer and Peters, 1980[26]; Husband et al, 1981[27]; Banfi et al, 1974[28]; Hanks et al, 1972[29]	463	Ultrasonography‡	75 (191/254)	87 (159/183)	80 (372/463)

*See text for definitions of Sensitivity, Specificity and Overall Accuracy.
†Reported results are for the whole body and for lymph nodes involved by lymphoma only.
‡Reported results are primarily for lymph nodes involved by lymphoma and lymph node metastases from testicular carcinoma.

sonography can be difficult to do; lymphography and gallium scanning can be difficult to interpret.

Fourth, the results vary also according to the number of patients in each individual study (7 to 416 patients).

Because of the great variability of the reported overall accuracy, sensitivity and specificity in the 92 individual reports, the mean value (equivalent to a weighted average) was used in comparing the various imaging modalities.

Accuracy of Various Imaging Modalities in Detecting Lymph Nodes Involved By Lymphoma and Lymph Node Metastases

Neck. Abnormal lymph nodes in the neck can be imaged by ultrasonography, CT or both. Ultrasonography has limited acoustic-beam penetration and cannot image the retropharyngeal space. CT has therefore become the primary imaging modality for detecting, localizing and siting pathologic neck lymph nodes. CT improves the diagnostic accuracy in detecting abnormal lymph nodes in patients who have had surgical treatment or irradiation.[95] It can show abnormal nodes that are not clinically palpable, such as those in the high lateral and retropharyngeal chains[95] and those deep behind the sternocleidomastoid muscle (nodes as large as 2.5 cm have been missed clinically in that area).[96] CT can also reveal the absence of cervical lymph nodes thought to be present clinically.[97] With the intravenous administration of contrast mate-

TABLE 4.—*Reported Accuracy of Lymphography and Computed Tomography in Detecting Lymph Nodes in the Abdomen and Pelvis Involved By Lymphoma and Lymph Node Metastases*

Type of Disease Reported	*Reference Nos.*	*Number of Patients*	*Sensitivity* Percent*	*Specificity* Percent*	*Overall Accuracy* Percent*
Lymphography					
Hodgkin's and non-Hodgkin's lymphoma	15,17,19,28-41	2,111	84 (619/737)	89 (1,176/1,321)	85 (1,795/2,111)
Testicular carcinoma	20,42-54	644	74 (259/350)	91 (268/294)	82 (527/644)
Other pelvic carcinomas	49,55-81	1,672	56 (311/551)	89 (877/986)	78 (1,305/1,672)
Prostate	55-71	811	56 (179/321)	84 (413/490)	73 (592/811)
Uterine cervix	72-77	650	52 (82/159)	93 (330/356)	81 (529/650)
Bladder	49,78	78	75 (15/20)	98 (57/58)	92 (72/78)
Endometrium	79	51	75 (12/16)	91 (32/35)	86 (44/51)
Ovary	80	68	69 (20/29)	100 (39/39)	87 (59/68)
Type not designated	81	14	50 (3/6)	75 (6/8)	64 (9/14)
Computed tomography					
Hodgkin's and non-Hodgkin's lymphoma	37-40,82-85	231	70 (57/82)	90 (131/146)	81 (188/231)
Testicular carcinoma	20,23-25,27,52-54,86	351	78 (153/195)	91 (117/129)	83 (291/351)
Other pelvic carcinomas	70,81,87-92	199	64 (51/80)	91 (108/119)	80 (159/199)
Prostate	70,87-89	84	50 (17/34)	92 (46/50)	75 (63/84)
Uterine cervix	87,90,91	33	94 (15/16)	82 (14/17)	88 (29/33)
Bladder	87,88,92	56	64 (9/14)	90 (38/42)	84 (47/56)
Type not designated	81	26	63 (10/16)	100 (10/10)	77 (20/26)

*See text for definitions of Sensitivity, Specificity and Overall Accuracy.

TABLE 5.—*Ranges of Sensitivity, Specificity and Accuracy From All 92 Reviewed Reports*

Type of Disease Reported	*Imaging Modality Reported*	*Reference Nos.*	*Range of Sensitivity Percent*	*Range of Specificity Percent*	*Range of Overall Accuracy Percent*
Mediastinal lymph node metastases from bronchogenic carcinoma	Gallium scanning	1-3	50.0-75.0	26.7-93.3	37.5-78.7
	Plain chest radiographs	2,4-6	5.6-73.9	84.2-100	59.5-80.7
	Conventional tomography	2,3,6	50.0-72.7	92.0-95.8	76.2-83.8
	Computed tomography	2,3,5-12	28.6-95.8	46.4-100	42.9-97.7
Hilar lymph node metastases from bronchogenic carcinoma	Gallium scanning	1-3	51.7-100	50.0-65.2	57.7-77.8
	Plain chest radiographs	5,6	52.9-66.7	82.0-85.0	71.4-77.1
	Conventional tomography	2,3,6,9	70.6-96.6	72.2-100	76.2-95.0
	Computed tomography	2,3,5,6,9,12	56.3-83.3	75.0-100	78.6-95.0
Lymph nodes involved by lymphoma and lymph node metastases in the abdomen and pelvis	Gallium scanning	13-16	16.7-79.3	93.5-100	62.9-88.4
	Excretory urography	17-19	28.6-54.5	Not reported	Not reported
	Cavography	15,16,18-20	43.3-75.0	33.3-100	46.2-69.1
	Ultrasonography	16,21-27	50.0-100	57.1-94.1	70.8-91.7
Hodgkin's and non-Hodgkin's lymphoma	Lymphography	15,17,19,28-41	13.3-100	56.0-100	58.5-95.7
	Computed tomography	37-40,82-85	33.3-100	75.0-100	68.8-90.3
Testicular carcinoma	Lymphography	20,42,54	44.4-87.5	66.7-100	61.9-88.9
	Computed tomography	20,23-25,27,52-54,86	14.3-93.5	80.0-100	58.8-96.6
Other pelvic carcinomas	Lymphography	49,55-81	28.6-100	29.2-100	46.7-94.4
	Computed tomography	70,81,87-92	29.4-100	50.0-100	69.2-93.3

rial, which is always used to distinguish nodes from the numerous branching neck vessels,[96] CT can sometimes show capsular or extranodal extension of tumor.[95-97]

Computed tomography also has severe limitations, however. The CT criterion for pathologic lymph nodes is based on their diameter. But histologic examinations have shown that neoplastic disease can be present in normal-sized lymph nodes (false-negative) and that some enlarged lymph nodes—that is, those of reactive hyperplasia, tuberculosis and other granulomatous diseases—are not necessarily malignant (false-positive).[95-97] Mancuso and colleagues reported tentative criteria for distinguishing nodes enlarged by tumor from "reactive" nodes or nodes enlarged by benign conditions.[96,97] These criteria need further validation.

Chest. Lymph nodes in the chest (mediastinum and hila) are generally assessed by gallium scanning, plain chest radiographs, conventional tomography and CT. Barium esophagography, angiography and tracheography are no longer used for the routine staging of lymphomas and carcinomas as they detect abnormal lymph nodes only indirectly, by compression or displacement of other structures.

The reported accuracy, sensitivity and specificity of gallium scanning in detecting lymph node metastases from bronchogenic carcinoma (Tables 1 and 2) vary widely. This is due to the difficulty of interpreting gallium scans.[2] The sensitivity is poor (62% to 71%), as small lesions are missed.[98] The specificity of gallium scanning varies. Many false-positive findings result from the nonspecific uptake of the radiopharmaceutical by benign inflammatory lymph nodes[14,98] and even by normal tissues. All of these limitations contribute to the poor overall accuracy (65% to 69%) of gallium scanning.

The data from Tables 1 and 2 comparing plain chest radiography, conventional tomography and CT show that plain chest radiography is the poorest method for detecting lymph node metastases in the mediastinum and hila (overall accuracy is 74% for both).

In the mediastinum, conventional tomography and CT have about the same overall accuracy for detecting malignant nodes (81% versus 83%), but conventional tomography is less sensitive (66% versus 82%) because lymph nodes must be large enough to displace mediastinal landmarks before they are detected by conventional tomography. Although conventional tomography is more specific (94% versus 84%), the sensitivity of CT makes it the best technique for detecting malignant mediastinal lymph nodes.

For hilar lymph notes, conventional tomography (using a 55-degree oblique projection) and CT have the same overall accuracy (84% versus 83%). Despite the greater sensitivity of conventional tomography (83% versus 70%), CT still seems to be the primary imaging modality for detecting malignant hilar lymph nodes for two reasons: It shows the relationships between the mass and hilar vessels and bronchi more clearly and it can also depict abnormal posterior hilar lymph nodes. In the staging of bronchial carcinoma, CT can at the same time show mediastinal extension of a hilar mass and mediastinal lymph node metastases. Further, one recent study showed that conventional tomography is not more sensitive or specific than CT.[99]

CT has the same limitations for detecting malignant lymph nodes in the chest as in the neck, the CT criteria being based on size.

Abdomen and pelvis. CT is the most sensitive imaging technique for detecting malignant mesenteric lymph nodes, despite its relatively large number of false-negative diagnoses.[100] Barium studies are not sensitive; in one study, results of barium examinations were abnormal in only three out of seven lesions proved by CT examinations.[100] Lymphography cannot opacify mesenteric lymph nodes.

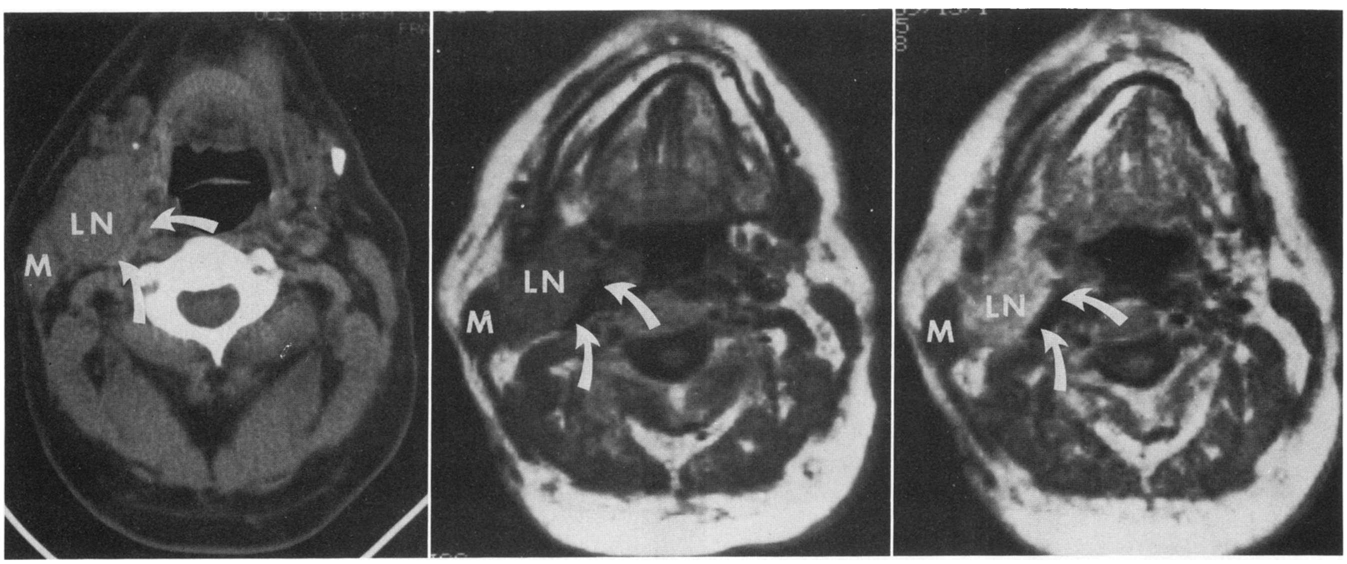

Figure 1.—Computed tomography (CT) and magnetic resonance (MR) imaging of cervical lymph nodes. **Left,** A contrast-enhanced CT examination of the neck, showing a large cervical lymph node **(LN)** on the right side. The mass and surrounding structures (sternocleidomastoid muscle **[M]** and vessels [curved arrows]) exhibit about the same intensity. **Middle** and **Right,** MR images at the same level as the CT image, showing two different combinations of imaging parameters: **Middle,** relaxation time (TR) = 0.5 sec and echo time (TE) = 28 ms; **Right,** TR = 1.5 sec and TE = 28 ms. MR imaging shows the cervical lymph node **(LN)** with more contrast resolution than CT. The best discrimination of the lymph node from fat is obtained with a short TR **(Middle).** Differentiation of lymph node from muscle **(M)** is best with a long TR **(Right).** There is excellent contrast between lymph node and vessels, which always appear dark, no matter which TR or TE is used **(Middle** and **Right).** In all projections, right is on viewer's left.

Many imaging techniques are used to detect malignant lymph nodes in the rest of the abdomen and in the pelvis (Tables 3 and 4). The overall accuracy of gallium scanning for imaging malignant lymph nodes is higher in the abdomen than in the chest (75% versus 65% and 69%), but gallium scanning has the same disadvantages here as in the imaging of the chest: a high rate of false-negative results, resulting in poor sensitivity (Table 3). Excretory urography and cavography are no longer used because of their poor sensitivity (34% and 49%, respectively). These two techniques provide only indirect evidence of enlarged lymph nodes and can only indicate bulky adenopathies. They give no more information than lymphography or CT.

Ultrasonography (Table 3) and CT (Table 4) have about the same overall accuracy, sensitivity and specificity for depicting abnormal abdominal lymph nodes. The two techniques have a common limitation, the criterion for pathology being based on lymph node size. Ultrasonography has additional limitations. It is less precise in detecting lymph nodes smaller than 2 cm in diameter[22,25] and bowel gas often makes it difficult to obtain adequate scans of the lower abdomen and pelvis.[27] In one study, 18 of the 23 false-negative results were of abnormal iliac lymph nodes.[26] The reported ultrasonographic results are mostly of retroperitoneal lymph nodes involved by lymphoma and retroperitoneal lymph node metastases from testicular carcinoma—two conditions that usually produce bulky adenopathies—and, therefore, reported results are weighted in favor of this modality. Ultrasonography is also difficult to do on obese patients because the abundance of subcutaneous and mesenteric fat greatly attenuates the sound beam. Other areas are difficult to evaluate by ultrasonography, such as the high retrocrural space.

The two principal techniques used currently to evaluate lymph nodes in the abdomen and pelvis are lymphography

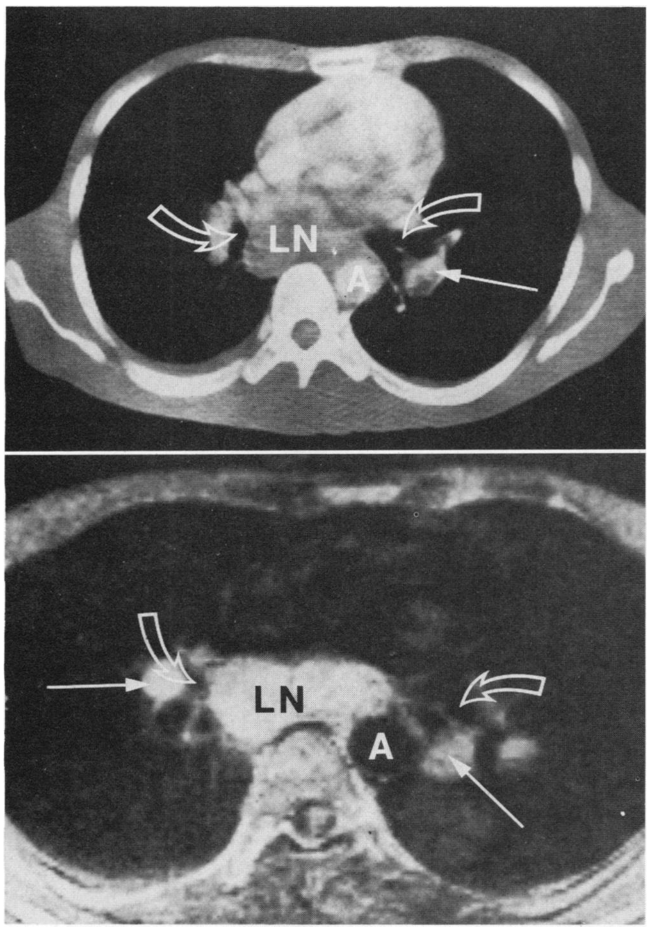

Figure 2.—Computed tomography (CT) and magnetic resonance (MR) imaging of mediastinal and hilar nodes in a patient with metastatic adenocarcinoma from an unknown primary site. **Top,** A contrast-enhanced CT examination at the level of the subcarinal space: subcarinal lymph nodes **(LN)** can be differentiated from the descending aorta **(A)** and the bronchi (curved arrows). Hilar lymph nodes are shown on the left side (straight arrow). **Bottom,** An MR image at the same level as the CT scan (relaxation time = 2.0 sec and echo time = 28 ms). The subcarinal lymph nodes are better differentiated from the vessels (descending aorta and heart). Furthermore, MR depicts bilateral hilar lymph nodes because of the excellent contrast between hilar vessels, bronchi (open curved arrows) and lymph nodes. In all projections, right is viewer's left.

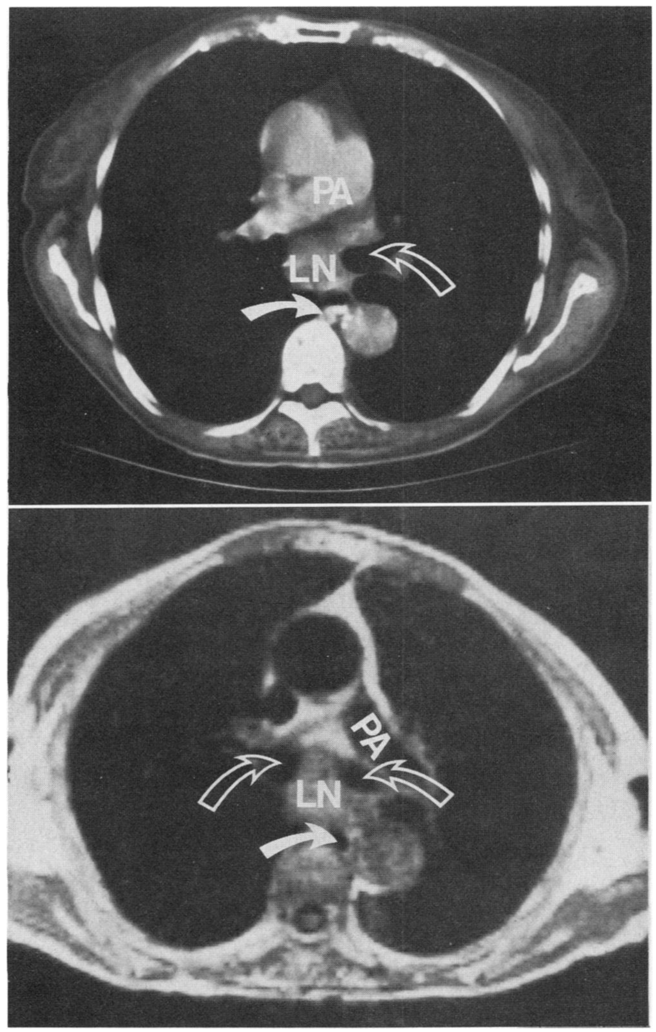

Figure 3.—Computed tomography (CT) and magnetic resonance (MR) imaging of mediastinal lymph nodes in a patient with oat cell carcinoma of the lung. **Top,** A CT examination at the level of the right pulmonary artery **(PA)** shows a lymph node **(LN)** in the subcarinal space that is readily differentiated from the main bronchi (open curved arrow). Solid curved arrow = azygos vein. **Bottom,** An MR image at the level of the left pulmonary artery **(PA)** (relaxation time = 0.5 sec and echo time = 28 ms). The subcarinal lymph node **(LN)** is well shown and differentiated from the main bronchi (open curved arrows), mediastinal fat, azygos vein (solid curved arrow) and left pulmonary artery. In all projections, right is viewer's left.

and CT (Table 4). The overall accuracy of lymphography for showing lymph nodes involved by lymphoma in these regions is slightly better than that of CT (85% versus 81%). The sensitivity of lymphography is significantly greater than that of CT (84% versus 70%). This may be due to the ability of lymphography to show Hodgkin's disease in lymph nodes considered normal by CT. As many as 10% of involved lymph nodes in Hodgkin's disease are either of normal diameter or only minimally enlarged.[101] This assumption has been challenged,[102] but the fact that lymphography is better than CT in this disease seems to be confirmed by the results of CT studies that comprised only patients with Hodgkin's disease.[37,84] The results are worse than those of other CT studies of only patients with non-Hodgkin's lymphoma.

Lymphography and CT have about the same overall accuracy (82% versus 83%), specificity (91% for both) and sensitivity (74% versus 78%) in showing lymph node metastases from testicular carcinoma. The overall accuracy (78% versus 80%) and sensitivity (56% versus 64%) of lymphography and CT are also comparable in showing lymph node metastases from other pelvic carcinomas. Both are less accurate and less sensitive than in depicting lymph node metastases from testicular carcinoma because nodes involved by pelvic carcinomas are generally only minimally enlarged or show only microscopic involvement. The specificity of the two methods in detecting lymph node metastases from testicular carcinoma and from other pelvic carcinomas is almost the same. CT can show pathologic lymph nodes in areas not depicted by lymphography and can show enlarged lymph nodes extensively replaced with tumor that do not fill with lymphographic contrast material. Therefore, CT is better for delineating the true extent, size and location of pathologic lymph nodes in the abdomen and pelvis. It can often also assess the state of other abdominal organs that may be affected, such as the spleen and liver. CT seems to be the best technique for planning radiation therapy and for the follow-up of patients.

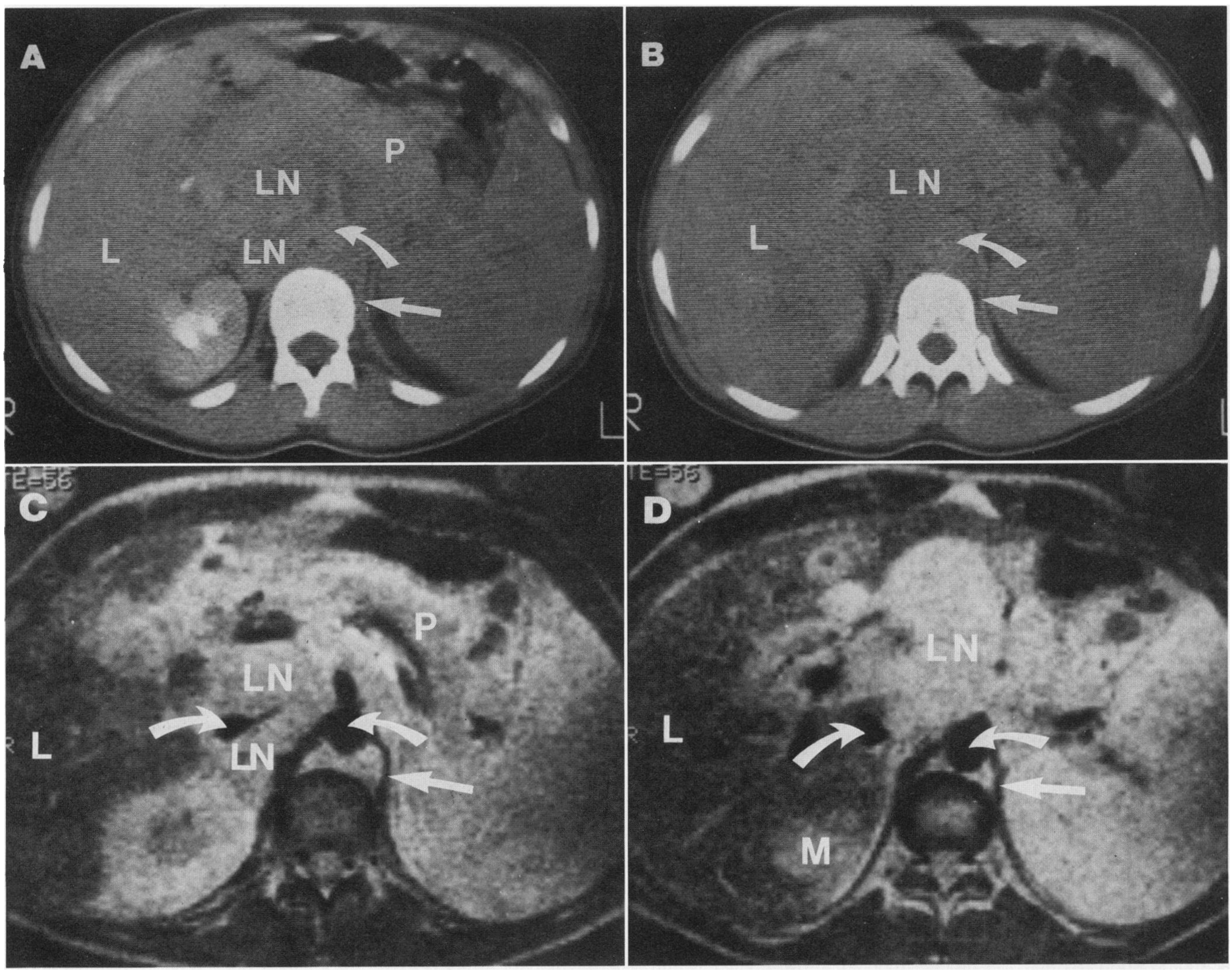

Figure 4.—Computed tomography (CT) and magnetic resonance (MR) staging in a patient with rhabdomyosarcoma. **A** and **B,** A contrast-enhanced CT examination of the upper abdomen: multiple retroperitoneal, retropancreatic, retrocrural and celiac lymph nodes **(LN)** are shown but the contrast between lymph nodes and surrounding structures (liver **[L]**, pancreas **[P]**, vessels [curved arrows] and diaphragmatic crura [straight arrows]) is very poor. **C** and **D,** MR images at the same level as **A** and **B** (relaxation time = 2.0 sec and echo time = 56 ms). The lymph nodes mentioned above are also shown but are better differentiated from the normal surrounding structures. Unlike CT, MR shows an important involvement of the hepatic hilum by lymph nodes **(D)** and a metastasis **(M)** in the right posterior hepatic lobe **(D)**. In all projections, right is viewer's left.

The striking difference between lymphography and CT is in the criteria used to determine lymph node pathology. Lymphography assesses the internal structure of the node; CT assesses the lymph node size.

False-positive findings with lymphography are uncommon, but in some instances it is difficult to make a differential diagnosis merely from altered internal structure of lymph nodes (filling defects). These can be due to tumor deposits or to other conditions such as fatty degeneration and postinflammatory scars. The technique, however, can usually differentiate reactive hyperplasia from tumor deposits. False-negative findings in lymphography are mainly caused by microscopic metastases (which cannot be detected by any imaging modality) and by nonopacification by routine bipedal lymphography of internal iliac, presacral, mesenteric, high retroperitoneal and retrocrural, renal, splenic and hepatic hilar lymph nodes. The primary drainage route of testicular carcinoma also cannot be opacified by bipedal lymphography. Many techniques are used to improve these false-negative results, such as direct testicular lymphography or percutaneous biopsy of the lymph nodes after lymphography.

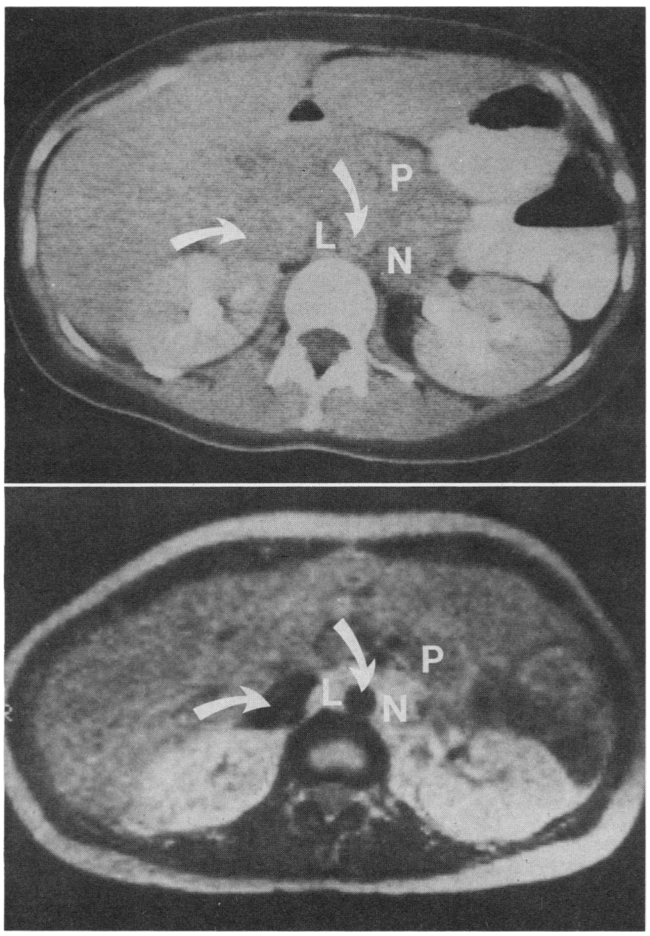

Figure 5.—Computed tomography (CT) and magnetic resonance (MR) imaging of retroperitoneal lymph nodes **(LN)** in a patient with ovarian carcinoma. **Top,** A contrast-enhanced CT at the level of the kidneys. The fatty planes between the aorta and the inferior vena cava (curved arrows) are obscured by a soft tissue mass but the distinction between this mass, the two great vessels and the pancreas **(P)** is poor. **Bottom,** An MR image at the same level as the CT scan (relaxation time = 2.0 sec and echo time = 56 ms). The left aortic and aortocaval lymph nodes are well shown and better differentiated from the aorta and the inferior vena cava, the pancreas and mesenteric vessels. In all projections, right is viewer's left.

False-positive results with CT are caused by enlargement of lymph nodes by conditions other than tumor deposits, such as reactive hyperplasia or inflammatory conditions. In some instances, false-positive readings are due to the difficulty in differentiating malignant lymph nodes from normal tissues (such as vessels, fluid-filled bowel loops, diaphragmatic crura and psoas minor muscle) and from other pathologic conditions (such as lymphoceles, retroperitoneal fibrosis, perianeurysmal fibrosis and congenital abnormalities of the inferior vena cava). False-negative readings by CT involve normal-sized lymph nodes containing tumor.

If lymphadenopathy is widespread—that is, if CT findings are positive for abnormal lymph nodes—no further imaging procedures are undertaken. In some instances, biopsy of the enlarged lymph nodes is done to avoid any false-positive CT diagnoses. In patients with normal or equivocal CT findings, the protocol for staging is controversial. Some investigators then do lymphography because it can show tumor deposits in normal-sized lymph nodes.[20,103] Others report that lymphography and CT are not complementary[53,54] and, therefore, a lymphadenectomy is preferentially done because it remains the only accurate staging modality.[54,89]

The Present Role of MR Imaging as a Staging Modality in Detecting Malignant Lymph Nodes

Magnetic resonance imaging will probably play an important role as a staging modality in the detection of malignant lymph nodes. It has excellent soft-tissue contrast resolution and it can distinguish malignant lymph nodes from normal and abnormal surrounding tissue, such as fat, muscle, vessels, adult thymus, thyroid, diaphragmatic crura and lymphoceles.[93] It also appears that the intrinsic relaxation measurements (spin-spin, or T2, and relative spin density) for acute inflammatory nodes differ from those for malignant lymph nodes.[94] Because MR imaging currently has low spatial resolution, however, it cannot show tumors in normal-sized lymph nodes. MR imaging can also play an important role in the follow-up of patients with surgical clips. Surgical clips do not affect the MR imaging, while they degrade CT scans.

In the neck, MR imaging can depict adenopathies not detectable by CT, such as a node near a nasopharyngeal carcinoma.[93] Depicting blood vessels without the use of contrast media is an additional advantage of MR imaging. With CT, unopacified blood vessels are often difficult to distinguish from lymph nodes (Figure 1). Therefore, MR imaging might improve the sensitivity by decreasing the number of false-negative results. MR imaging can differentiate enlarged acute inflammatory lymph nodes from enlarged malignant nodes,[94] thereby increasing the specificity. MR imaging gives fewer false-negative and false-positive results than CT in imaging the neck, suggesting its greater overall accuracy in detecting lymph nodes involved by lymphoma and lymph node metastases in this region.

MR imaging can depict abnormal hilar lymph nodes better than CT (Figures 2 and 3)[93]; therefore, it can decrease the number of false-negative results and improve the sensitivity. Furthermore, the ability of MR imaging to distinguish some types of inflammatory lymph nodes from enlarged malignant lymph nodes improves specificity.[94]

At present, MR does not approach the results of CT in imaging mesenteric lymph nodes because of its longer imaging time and the mesenteric and bowel motion in several directions.

In the abdomen and pelvis, MR imaging has the same advantages as CT in showing the true extent, size and site of abdominal lymph nodes and the involvement of other organs (Figure 4).[93] Like CT, MR imaging can show adenopathies in areas not routinely opacified by bipedal lymphography and it can show lymph nodes totally replaced by tumor. At the present time, MR imaging cannot detect microscopic metastases or those in normal-sized lymph nodes because of poor spatial resolution. Two previous studies have shown that MR imaging can distinguish abnormal lymph nodes from retroperitoneal tissue such as vessels, diaphragmatic crura and muscles (Figures 4, 5 and 6) and from some other disease conditions, such as lymphoceles.[93,94] It can also differentiate acute inflammatory lymph nodes from those involved by lymphoma or metastatic deposits. It appears, therefore, that MR imaging can improve the sensitivity and specificity and thus the overall accuracy of the detection of adenopathies in the abdomen and pelvis over those accomplished by all other imaging modalities, including CT.

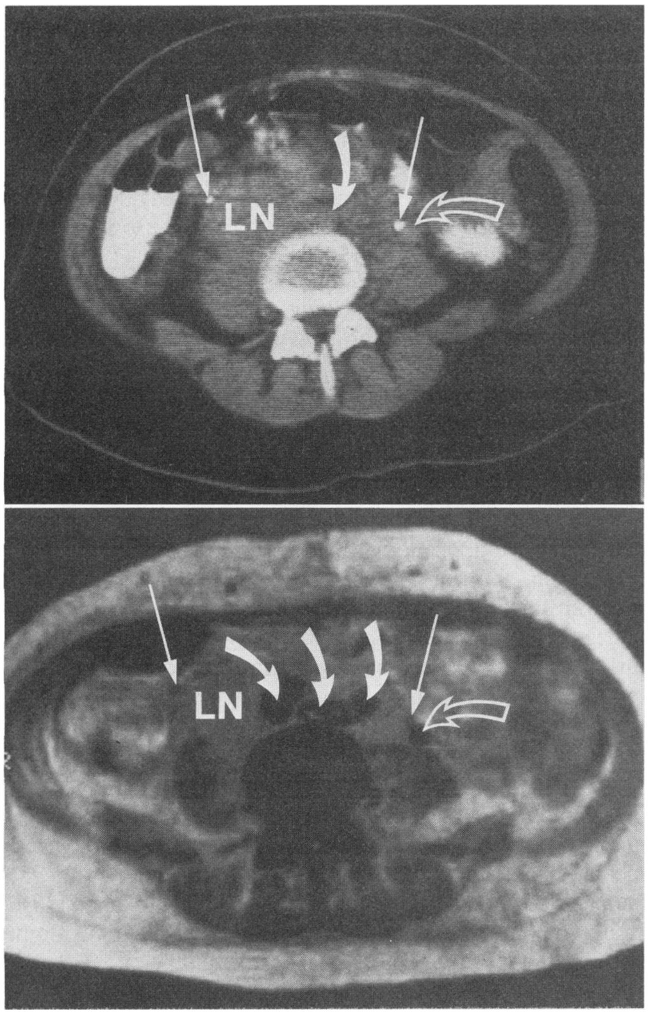

Figure 6.—Computed tomography (CT) and magnetic resonance (MR) imaging of retroperitoneal lymph nodes in a patient with non-Hodgkin's lymphoma. **Top,** A contrast-enhanced CT at the level of the aortic bifurcation showing several retroperitoneal lymph nodes **(LN)** that displace the two ureters (straight arrows) but cannot be readily distinguished from the great vessels (solid curved arrows). **Bottom,** An MR image at the same level as the CT scan (relaxation time = 2.0 sec and echo time = 28 ms). The retroperitoneal lymph nodes are shown with better contrast resolution than with CT, and there is clear differentiation between lymph nodes and great vessels. MR shows the presence of an enlarged left gonadal vein (open curved arrow) and of lymph nodes between the right psoas muscle and lumbar column. The two ureters cannot be readily identified, however. In all projections, right is viewer's left.

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